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COMMERCIAL CULTURE OF *OREOCHROMIS SPILURUS* IN OPEN SEAWATER CAGES AND ONSHORE TANKS

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Abstract

Trials were conducted to establish commercial-scale production of all stages of *Oreochromis spilurus.* Fry were produced in a tank using recycled fresh water. Fingerlings were grown in full strength sea water either in cages in the open sea or in onshore tanks filled with water from the sea. Very promising results were obtained in terms of fish growth, survival and product quality, opening up significant new opportunities for the expansion of tilapia culture in tropical and subtropical seas.

Introduction

As well as being highly sought in some parts of the world, several biological characteristics make tilapias prime candidates for aquaculture in the tropics and subtropics (Balarin, 1979). In particular, their tolerance to a wide range of temperatures, their relative ease of reproduction and their largely herbivorous nature give them a distinct advantage over more sensitive carnivorous species which are more expensive to produce. Indeed, interest has been steadily growing in tilapia culture worldwide during the last three decades or so, with traditional systems being intensified and new systems being installed on a more modern basis.

A serious obstruction to continued expansion is the lack of inland water resources. In most cases, commercial tilapia production has been restricted to fresh water. The ability of tilapia to thrive in brackish and sea waters has been extensively tested (Payne, 1983; Stickney, 1986; Al-Amoudi, 1987; Watanabe et

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al., 1989; Suresh and Lin, 1992). Adaptation of tilapia to seawater culture could lead to significant expansion of tilapia production worldwide, particularly in coastal areas of the tropics and subtropics. Open sea water is usually of better quality and has a more stable temperature and oxygen level than fresh water, reducing stress on the fish and allowing improved growth. Cage culture eliminates the need for continuous pumping and has enormous potential especially in low energy tidal coastal areas where relatively cost effective cages can be used.

The main objective of this trial was to establish the production of *Oreochromis spilurus* on a commercial scale throughout the entire life cycle from fry production in recycled fresh water to fattening in full strength sea water using open sea cages and onshore tanks.

Materials and Methods

The trials were conducted in Malta (central Mediterranean). *O. spilurus*, whose original stock came from Kenya some fifteen years earlier, were used. Preliminary laboratory scale experiments were carried out by the present author (unpublished) and others (Al-Ahmad et al., 1988) and showed that *O. spilurus* is very tolerant to high salinity.

Fry production. Spawning and larval rearing took place in specially designed tanks (Fig. 1) filled with fresh water and fitted with a recycling water system. Each circular concrete tank had a diameter of 10 m, a depth of 1 m and a volume of approximately 78 m^3. There was a 20 cm (width) channel around the perimeter of the tank surface. The inner lip of the channel, which was an integral part of the tank wall, was 5 cm wide. The lip was 5 mm below the water surface of the tank to permit the young fry (but not the adults) to swim into the channel. The water in the channel was 3-10 cm deep. The channel was completely drainable at two points where the fry could be collected by allowing the water to flow out of the channel via the fry discharge pipe, through a handheld net and into a plastic container. Each tank was stocked with sixty female and twenty male broodfish weighing 150-300 g each. Fluorescent tubes (14 h on:10 h off photoperiod regime) were placed around the edges of the tanks to attract the fry to the tank sides and the channel. To obtain the desired number of fry, more than one breeding tank was used, in addition to other facilities.

Salt water acclimation. After collection, fry were transferred to 0.3 m^3 fiberglass troughs with recycled fresh water at 25°C. Fry collected during a three day period were treated as one batch. They were weaned directly onto commercial dry feed (Proaqua, Holland). For the first three weeks, the feed contained 30 mg of 17α-methyltestosterone per kilogram; afterwards, the fry were fed normal untreated feed. Three weeks after the termination of the hormone-treated food, fry were acclimatized by gradually introducing sea water to the troughs over a 48 h period. They were left to settle in full strength sea water (37‰) for a further two weeks and, at eight weeks, the seawater acclimated fry were transferred to the nursing tank.

Nursing. Twenty square fiberglass tanks (2.5 m^3 each) with partially recycled sea water were used to nurse the fry to 51 g fingerlings over a 16 week period. The final density in these tanks was 35-40 kg/m^3. Stocking data for the nursing phase are shown in Table 1.

Growout. At the end of June, when the ambient temperature was 22°C, 36,080 nursed fish were transferred to eight sea cages and eight onshore seawater tanks for growout. They were grown for five months and harvested at the end of November when the temperature dropped to 20°C. From the middle of July to the end of October, the sea water temperature remained steady at 25-26°C. Stocking data for the growout phase are shown in Table 2.

Sea cage trials. Sea cage trials were carried out in eight 125 m^3 floating wooden cages (Kames, Scotland; total rearing volume 1000 m^3) in open sea water with a salinity of 37-38‰.

Onshore tank trials. Onshore tank trials were carried out in eight 16 m^3 tanks (total rearing volume 128 m^3) using water drawn from the open sea with a salinity of 37-38‰.

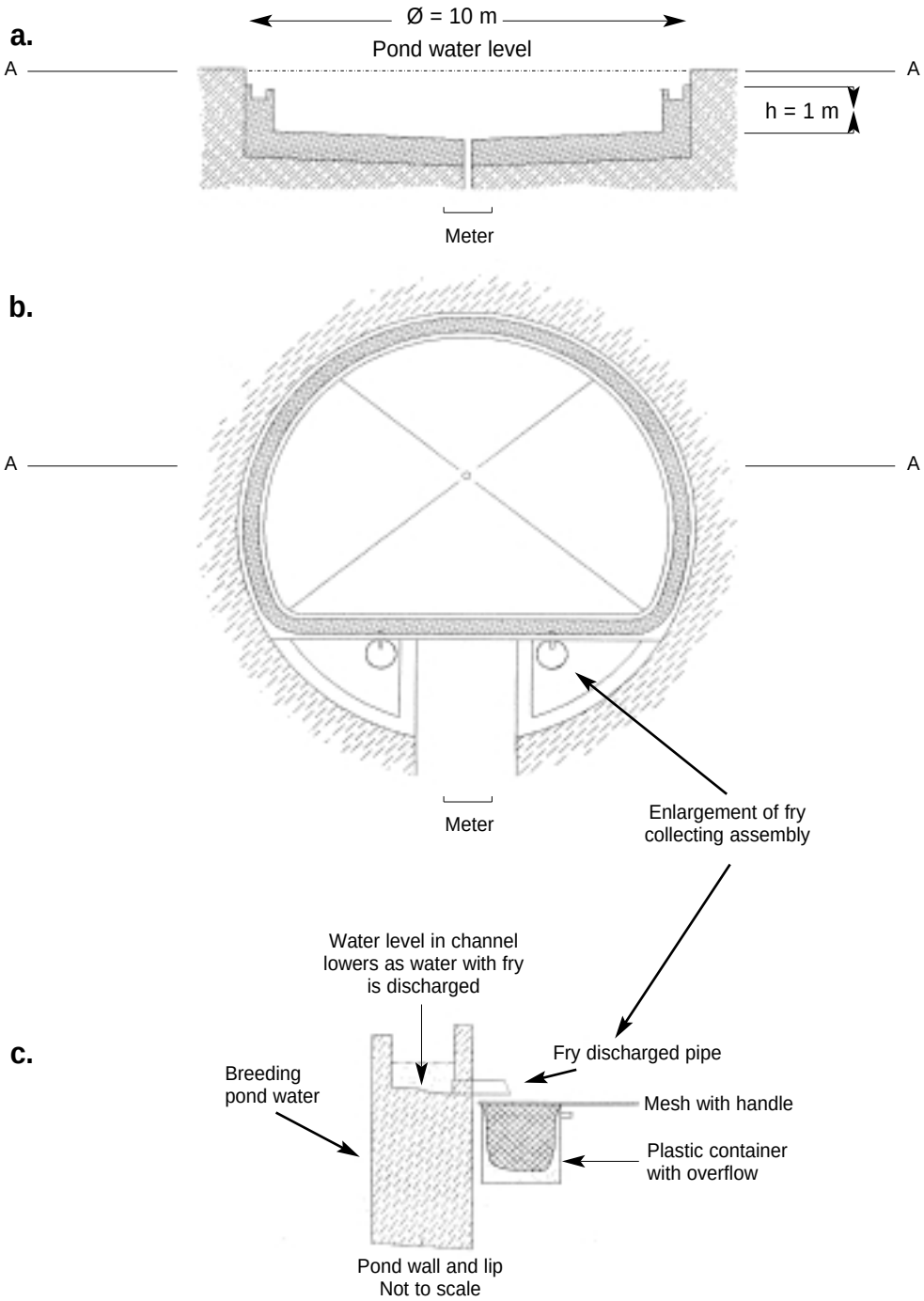

Fig. 1. A cross section (a) and a top view (b) of a spawning tank and a cross section (c) of the fry collecting assembly.

Table 1. Stocking and harvest in the nursing phase.

Stocking	
Date of stocking	March 1-10
Total water volume	50 m^3
Number of fish stocked	40,500
Average individual stocking weight	5.2 g
Total stocking biomass	210.6 kg
Stocking density	4.2 kg/m^3
Harvest	
Date of final harvest	June 28-30
Days of growth	110
Number of fish harvested	36,455
Survival	90%
Average individual weight at harvest	51 g
Daily growth increment per fish	0.42 g
Gross yield	37.2 kg/m^3
Net yield	33.0 kg/m^3
Total feed	Fed to satiation — not recorded

Feeding. In the broodstock tank and growout facilities, fish were fed three times daily; in the fry and nursing facilities, fish were fed five times daily. Fish were fed dry pressed pelleted tilapia feed (Proaqua; 45% protein for fish up to 20 g and 35% for fish over 20 g) according to feeding tables published by the feed manufacturer.

Results

Fry were collected twice daily from the spawning tanks. An average of 340 fry were collected per day per tank, representing a production rate of 130 fry/m^3/month. The system worked very efficiently in that no fry were ever noted to be left behind, either in the main tank or in the peripheral collecting channel. This is important as it ensures that all fry begin receiving hormone-treated feed within 24 h of complete absorption of the yolk sac. It also ensures size uniformity within each batch of fry. Indeed, throughout the trials, very uniform growth was noted and grading was performed only once, during the transfer of the fish from the nursing to the growout facilities. The results of the nursing stage are shown in Table 1; the results of the growout stage are shown in Table 2.

At harvest, fish varied from 450 to 500 g with the average being 483 g in the sea cages and 475 g in the onshore tanks. At the end of the growout period, 15 tons of fish were harvested from the cages and almost 1.9 tons from the onshore tanks. The final density in both the sea cages and the onshore tanks was close to 15 kg/m^3. The food conversion ratios were 1.625 and 1.655 in the cages and tanks, respectively.

Table 2. Stocking and harvest in the growout phase.

	Sea cages	*Onshore tanks*
Stocking		
Date of stocking	June 28-30	June 28-30
Total area (m^2)	200	128
Total water volume (m^3)	1000	128
Number of fish stocked	32,000	4,080
Average individual stocking weight (g)	51	51
Total stocked biomass (kg)	1,632	208
Stocking density (kg/m^3)	1.63	1.63
Harvest		
Date of final harvest	November 28-30	November 28-30
Days of growth	150	150
Number of fish harvested	31,250	3,978
Survival (%)	97.7	97.5
Average individual weight at harvest (g)	483	475
Daily growth increment per fish (g)	2.88	2.83
Gross yield (kg/m^3)	15.1	14.8
Net yield (kg/m^3)	13.46	13.14
Total feed (kg)	21,870	2,783
Food conversion ratio	1.625	1.655

No signs of sexual maturity were observed in the growout systems, further enhancing the food conversion ratio and growth. No wild fry, typical of freshwater pond culture systems, were noted.

Persistent, but very low (2-2.5%), mortalities were recorded in both the cage and the tank systems. Pathological investigation revealed that *Vibrio harveyi* was the responsible pathogen. It was observed that this pathogen causes blindness in tilapias.

Discussion

Although a number of studies have dealt with the acclimation of *O. spilurus* to full strength sea water (Al-Ahmad et al., 1988; Cruz et al., 1990; Jonassen, 1994), the process has not yet been commercialized in spite of dramatic advances in aquaculture production worldwide. The trials described in this study clearly show that under favorable temperature regimes, the culture of this species can quickly develop into a large-scale industrial activity with the best potential offered by open sea cage culture. The site where the cage culture trials were conducted is an open sea site with waves up to 4 m, showing that this species adapted well to the open sea where currents and other water movements are normally much more pronounced than in freshwater and sheltered marine environments.

A serious drawback to the large scale

commercialization of *O. spilurus* production is the low winter seawater temperature which requires that all stocks be harvested by the end of November. In the Mediterranean, this coincides with the low in tourism and therefore poses a serious marketing problem. Indeed, in spite of the significant success of this project in terms of fish growth, food conversion ratio and overall production costs, it had little commercial follow-up. This was due to the poor regional market demand, the restricted growing season and the concomitant rapid expansion of the culture of true marine species (sea bass and sea bream) which enjoy a longer tradition and greater popularity among Mediterranean and, more generally, European consumers. The author envisages, however, brighter prospects for this commercial activity in tropical and subtropical countries of Asia, Africa and Central and South America. Even there, however, opportunities may be limited in areas where the sea water is too cold for tilapia culture.

To study the problem of low winter temperatures limiting the marketing season for fresh or live fish, one tilapia cage was left in the sea over winter. To minimize stress, no operations such as grading or net changing were carried out. Nevertheless, all the fish in this cage were lost when the temperature dropped to 15°C in late January. Presumably, it was the combination of high salinity and low temperature that proved too stressful, since tilapia can survive (albeit at a low percentage) under similar temperatures in fresh water (unpublished).

The absence of any signs of sexual maturity in the growout systems may be due to the combination of the hormonal sex reversal treatment and the saltwater environment.

The fish were of excellent quality as testified by a number of well-established buyers who stated that their quality was markedly superior to that of tilapia grown in fresh water. Occasionally the tank-grown tilapia had the “earthy” taste typical of pond-reared fish. This was not observed in the cage-reared fish.

The identification of *Vibrio harveyi* as the pathogen responsible for the mortality is interesting since up to the time of these trials this bacterium had only been known to cause pathology in shrimps; indeed this represents the first record of this disease in farmed finfish. Like most *Vibrio* outbreaks, this disease is normally associated with stress. It is likely that in this case the high salinity caused chronic continuous stress which, although the fish seemed to cope well, in the end was manifested in the chronic disease. The excellent growth, FCR and survival, however, made this outbreak economically insignificant.

The wooden cages deteriorated much faster in the sea water than in fresh water. As a result, they are quickly being replaced with more robust materials, most commonly high density polyethylene.

Acknowledgement

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